## Interested?

The *Advanced VAV System Design Guide* provides recommendations to help engineers improve the efficiency of large HVAC systems. It focuses on built-up variable-air-volume (VAV) systems in multi-story commercial office buildings in California or similar climates. But much of the information is useful for a wider range of system types, building types, and locations. For example:

- Selection guidelines for VAV terminal units apply equally well to systems using packaged VAV air handlers.
- Recommendations on zone cooling load calculations are relevant regardless of system type.

Key next steps include:

- *HVAC engineers:* Adopt the best practices recommended in the *Design Guide.*
- *Owners/managers of large commercial buildings:* Encourage HVAC engineers and mechanical systems staff and contractors to read and use the *Design Guide.* Check with utility companies for efficiency program information.
- *HVAC equipment manufacturers & building simulation developers:* Integrate the PIER results into HVAC design and modeling tools, and further develop the fan models created by the PIER researchers.

This project was part of the *Integrated Energy Systems: Productivity and Building Science* program. To learn more, visit www.newbuildings.org/pier.

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# Integrated Design of Large HVAC Systems

## Optimizing the Design and Control of Large VAV Systems

## Large HVAC: A Systems Perspective

Large HVAC systems typically are not designed with a systems' perspective. Component selection is usually based on the features of individual components rather than on system-wide impacts. As a result, large HVAC systems use significantly more energy than necessary.

This project conducted an in-depth investigation of the problems causing sub-optimal performance.

*Relief fan*

The research focused on the air side of built-up VAV systems in commercial buildings larger than 100,000 square feet and quantified problems with component and system selection, building controls, and operation that cause energy inefficiencies.

This data was used to determine potential savings and develop a *Design Guide* for smarter, energy-efficient designs that can have a dramatic impact on large HVAC design.

## Advanced VAV System Design Guide

***The Advanced VAV System Design Guide promotes efficient, practical designs that can be implemented successfully today.***

The *Design Guide* addresses the air side of variable-air-volume (VAV) systems with chilled water plants. Key research findings include:

- Reduce design system static pressure.
- Employ demand-based static pressure reset.
- Use low-pressure plenum returns/relief fans.
- Employ demand-based, supply temperature reset to reduce reheat energy and extend economizer effectiveness.
- Design fan systems to turn down and stage efficiently.


*Air-flow monitoring station at fan inlet*

- Size terminal units to balance energy impacts of pressure drop and minimum air flow control.
- Set terminal unit minimums as low as required for ventilation. Use intelligent VAV box control schemes to prevent stratification.
- Employ demand-based ventilation controls for high-density occupancies.
- Design conference rooms to provide ventilation without excessive fan energy or reheat.
- Design 24/7 loads to allow efficient system turn-down and use of economizer cooling.

## Building and Statewide Energy Savings

The type of large HVAC system addressed by this research accounts for an estimated 20% to 25% of the state's cooling capacity. For buildings that follow the *Design Guide's* recommendations:

- HVAC electricity savings would be approximately 25%, equal to 12% of total building electricity consumption.
- Natural gas heating savings would be approximately 41%.

If the recommendations in the *Design Guide* were implemented in 10% of California office buildings with VAV reheat systems over each of the next 10 years, the following savings could be achieved:

- First-year statewide electricity savings: 2,220 MWh. Savings after 10 years: 22,200 MWh/yr.
- Cumulative electricity savings: 122,100 MWh ($16.7 million).
- Cumulative gas savings: 6,980,000 therms ($5.8 million).
- Total net savings over 10 years: $22.5 million.

*Relief fan discharge*